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21世纪初 中国石油地质理论问题 与陆上油气勘探战略

贾承造 著



**CHINESE PETROLEUM GEOLOGY AND ONSHORE
EXPLORATION STRATEGY
IN THE EARLY 21st CENTURY**

石油工业出版社

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内 容 提 要

本书全面论述了新形势下中国陆上新一代石油地质理论——21世纪初我国陆上岩性、前陆、深层油气勘探理论的内涵,未来油气勘探领域的石油地质理论问题,中国石油陆上油气勘探的总体战略,各盆地区域油气勘探战略和油气勘探组织管理与科技发展战略。充分反映了作者面对21世纪初中国石油工业发展的新形势,新的机遇与挑战,对中国陆上新一代石油地质理论问题和新的油气勘探战略的深入思考。

本书主要供从事油气勘探生产与研究的科技人员使用,也可作为大专院校与科研院所相关专业师生与科技人员的参考书。

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序

21 世纪初中国石油工业进入一个新的历史发展阶段,我国石油生产长期稳定增长,天然气生产进入快速发展时期,随着国民经济快速增长,保障国家石油安全面临着巨大压力,中国石油工业进入充满发展机遇与压力的时期。在中国石油工业需要新的石油地质理论和正确的陆上油气勘探战略之际,中国石油天然气股份有限公司总地质师、中国科学院院士贾承造教授的《21 世纪初中国石油地质理论问题与陆上油气勘探战略》一书正式出版了。该书全面论述了新形势下中国陆上新一代石油地质理论的内涵、未来油气勘探领域的石油地质理论问题、中国石油陆上油气勘探的总体战略、各盆地区域油气勘探战略和油气勘探组织管理与科技发展战略。作者是一位有很高学术造诣和丰富勘探经验的石油地质学家和勘探专家,长期工作在勘探生产和科学研究的第一线,这本著作充分反映了他面对 21 世纪初中国石油工业发展的新形势,新的机遇与挑战,对中国陆上新一代石油地质理论问题和新的油气勘探战略的深入思考。

回顾我国陆上石油勘探和石油工业的发展过程,每一次大的发展,都伴随着石油地质基本规律认识的突破和新理论的产生。20 世纪 50 年代末(1959 年)在松辽盆地发现大庆油田以后,原油年产量达到几千万吨伴随的是陆相石油地质理论的发展。70 年代末(1978 年)原油年产量达到 $1 \times 10^8 \text{ t}$ 的时候,伴随的是断陷盆地复式油气聚集带理论的发展。进入 21 世纪初,中国石油工业进入一个新的历史发展阶段,相信随着《21 世纪初中国石油地质理论问题与陆上油气勘探战略》一书的出版,新一代石油地质理论的不断形成、发展与完善,以及中国陆上新的油气勘探战略的实施,必将带动中国陆上油气勘探的大发现、大突破,迎来中国陆上石油储量增长的新高峰和天然气储量的快速增长,推动中国陆上石油工业的大发展。

21 世纪初及今后相当长的时期,预期我国国民经济将快速增长,油气供给面临着严峻的挑战,希望有更多的石油地质学家与勘探工作者勇敢地承担起新时期中国石油地质理论发展的重担,承担起推动新时期油气勘探事业大发展的重担,共同推动中国石油工业长期持续快速发展。希望在《21 世纪初中国石油地质理论问题与陆上油气勘探战略》一书的指导下,经过广大石油科技与勘探工作者的共同努力,新一代石油地质理论尽快形成,共同铸造中国石油工业新的辉煌!

陈耕

2005 年元月

前 言

我国石油工业有着悠久和光荣的历史,我国石油勘探家与地质学家在油气勘探历史中做出过重大贡献,在石油工业的发展过程中,石油储产量每次上一个大台阶,都伴随着对我国石油地质基本规律认识的一次飞跃。在 20 世纪 50 年代末我国在松辽盆地发现大庆油田,伴随着陆相盆地生烃理论的发展,突破了海相油气理论的局限。70 年代末我国的原油产量上了年产 $1 \times 10^8 \text{t}$, 主要是渤海湾盆地的突破,伴随着断陷盆地复式油气聚集带理论的发展。进入 21 世纪初,中国石油工业进入一个新的历史发展阶段,国民经济快速增长,国内油气供给面临着严峻挑战;油气勘探在东部和中西部全面展开,天然气勘探后来居上,油气勘探对象日益多元化,多种类型盆地、复杂类型油气藏、不同勘探程度地区、新老勘探领域都成为勘探的重点与热点,我们面临着全新的形势;如何针对今后的油气勘探发展新的石油地质理论,指导油气勘探新发现与新突破,保持和提高国内油气稳定供应,是目前摆在石油勘探家与地质学家面前的重大课题,是我国石油地质理论发展与油气勘探面临的挑战和新机遇。中国石油工业需要新的石油地质理论和正确的陆上油气勘探战略。

近年来,油气勘探中面临的理论挑战、石油工业界勘探实践、层序地层学等国外新地质理论的引入,以及以地震、钻井为核心的工程技术进步,推动了新一代石油地质理论的形成和发展。作者认为新一代石油地质理论正在逐步形成与发展之中,它面对 21 世纪初陆上油气勘探提出的新理论挑战,集中了近年油气勘探实践的新发现和新认识,并吸取了石油地质基础学科研究新成果,是我国石油勘探与科研人员智慧的集体结晶。可称为“21 世纪初我国陆上岩性前陆深层油气勘探理论”,包括:岩性地层油气藏石油地质与勘探理论;我国中西部油气盆地构造地质、石油地质与勘探理论;陆相前陆盆地冲断带石油地质与勘探理论;叠合盆地中下部组合(深层)石油地质与勘探理论;天然气地质与富集理论;非常规油气资源地质理论与勘探开发技术;以及油气资源评价与剩余资源分布预测等。

同时,面对 21 世纪初中国陆上石油勘探面临的资源形势与经济技术条件,作者认为 21 世纪初我国陆上油气勘探战略是:以岩性地层油气藏、前陆盆地冲断带、叠合盆地中下组合(深层)及老区精细勘探等四个领域,和松辽、塔里木等七大盆地作为勘探主要领域和主要地区;加强石油勘探,加快天然气勘探,积极推进新盆地、新领域的风险勘探;大力发展应用地震、钻井等新技术;加强地质综合研究与石油地质基础学科研究;重视非常规油气资源与新能源等。

本书是由作者近年已发表与正在发表的部分学术论文和会议发言共 47 篇编辑而成的,是作者近年来工作、学习与思考的初步总结。作者在多年的科学研究与勘探实践中,深深体会到科学新发现来源于现场工作的第一手资料,勘探新思想来源于一线勘探家的

找油实践。正是这些科学新发现和勘探新思想,推动着新的石油地质与勘探理论的形成,指导着油气勘探事业的发展。近年来作者在石油地质研究与油气勘探实践中认真探索耕耘,有一些收获与成果,有些成果已受到勘探实践的检验,为推动我国陆上油气勘探起了一定作用。但作者感触更多的是石油工业勘探界全体同行近年的努力和辛勤工作,在复杂的地质条件下取得了重大勘探进展,并创造了许多新认识、新理论。作者希望能汲取和综合石油界同行的新认识、新理论,应用于中国石油的油气勘探之中,并适时发展出新一代的我国石油地质与勘探理论,形成我国陆上油气勘探战略。

作者深感作为石油勘探家与石油地质学家,我们对保障国家石油安全,保证国民经济繁荣发展,负有光荣的历史责任。尽管面临许多困难和风险,作者坚信在全国石油勘探战线同行的共同努力下,我国石油天然气勘探事业方兴未艾,我们一定能迎来我国石油储量增长的新高峰,迎来天然气工业的辉煌时代。作者衷心希望通过这本书的出版能尽自己的一份微薄之力。

本书分上、下两卷共六篇。上卷主要讨论了 21 世纪初中国石油地质理论问题,包括第一、第二、第三篇。其中:

第一篇:论述了中国陆上剩余油气资源与未来主要油气勘探领域;论述了岩性地层油气藏、前陆盆地冲断带、叠合盆地中下部组合(深层)等未来主要油气勘探领域的地质理论问题,探讨了 21 世纪初新一代石油地质理论内涵,提出了“21 世纪初我国陆上岩性前陆深层油气勘探理论”。

第二篇:论述了肩负着中国石油战略接替重任的中西部盆地大地构造背景、构造特征与石油地质。指出小型克拉通盆地、前陆冲断带与叠合复合含油气系统是中西部盆地典型的地质构造特征与含油气特征。塔里木盆地及西部其他盆地是特提斯北缘盆地群这一世界上重要的巨型天然气聚集区的一部分。受印藏碰撞引起的喜马拉雅运动统一大地构造背景控制,中西部盆地具有油气晚期成藏的鲜明特色。

第三篇:论述了塔里木盆地的类型、构造演化史与构造特征,以及石油地质条件,指出塔里木盆地是由古生界克拉通盆地和中、新生界前陆盆地组成的大型叠合复合盆地。具有多次沉降隆起的复杂构造演化史、多油源、多含油层系、多期成藏的叠合复合含油气系统的特点。油气分布主要受古生界克拉通古隆起和中新界前陆冲断带控制。奠定了叠合复合盆地理论和塔里木盆地石油地质基础,对指导塔里木盆地,乃至其他中西部盆地的油气勘探具有重要作用。

下卷主要讨论了 21 世纪初中国陆上油气勘探战略,包括第四、第五、第六篇。其中:

第四篇:汇总了作者在 2000—2004 年历次中国石油勘探年会及勘探技术座谈会上的工作报告,论述了中国石油陆上油气勘探的总体战略和年度部署,历史地记录了作者对油气分布规律、勘探部署决策、勘探战略与组织管理的认识轨迹和思路形成,以及作者近年对地震、钻井等勘探技术发展和地质综合研究等方面的认识及发展规划、工作要求。

第五篇:论述了各盆地区域油气勘探战略。主要摘选了作者近年在塔里木、准噶尔、鄂尔多斯、柴达木、酒泉和吐哈等勘探会议与生产现场的有关讲话,包括各盆地油气勘

探形势分析、油气地质条件与分布规律的认识、油气勘探战略部署和相应的技术对策等。

第六篇：论述了新形势下油气勘探组织管理与科技发展战略。包括油气勘探工作的组织管理、主导勘探技术发展方向、石油基础科学研究的现状与加强的途径，以及石油高等教育的发展等问题，有历史的回顾、现状的分析和希望与对策。

作者衷心地感谢王涛老部长、陈耕总经理、邱中建院士多年的关怀；感谢翟光明院士、戴金星院士、张一伟教授、龚再升教授、牟书令教授、王宜林教授的指导；感谢赵政璋、赵文智、金之钧、周新源、宋岩、冉隆辉、何自新、杜金虎、周海民、李丕龙、邹才能、胡素云等同事和朋友的长期支持；感谢本书中引用的研究成果与论文的所有合作者，作者尽可能一一注明；感谢魏国齐、钱凯、郭召杰和林永汉编辑为本书出版付出的辛勤劳动，特别是魏国齐花费了大量心血。

FOREWORD

The beginning of the 21st century has ushered in a new historic stage of rapid development for Chinese petroleum industry. In China, crude oil production has undergone a continuous and stable increase for a long time, and natural gas production has entered a fast growth period. Yet with rapid national economic growth, China is confronted with considerable pressure to ensure the safety of its oil supply. Chinese petroleum industry is, therefore, facing with both opportunities and challenges. At the moment, when the industry needs the latest petroleum geological theories and key guidance of onshore oil and gas exploration strategies, the book *"Chinese Petroleum Geology and Onshore Exploration Strategy in the Early 21st Century"* is officially published. The author of the book, Mr. Jia Chengzao, is Chief Geologist of PetroChina, and an academician of the Chinese Academy of Science. The book expounds China's new onshore petroleum geological theories for the new situation, perspectives on issues facing future oil and gas exploration, overall strategies of onshore oil and gas exploration for PetroChina, regional strategy of oil and gas exploration targets in various basins, as well as strategies concerning about organizational management and scientific technology development. The author is a famous petroleum geologist and explorationist, who has endowed with high academic attainments and rich exploration experience. Mr. Jia Chengzao has been working for quite a long time on the front line in exploration, production and R&D fields. This work reflects his deep thought on the new situation of the petroleum industry development in the early 21st century, on new opportunities and challenges, and on the issues surrounding new petroleum geological theories and oil and gas exploration strategies.

Looking back on the development process of onshore petroleum exploration activities and petroleum industry in China, it is evident that every big step in achievements is accompanied by breakthroughs of understanding of basic laws of petroleum geology, and the birth of new theories. By the end of 1950s (1959), when Daqing Oilfield was discovered in Songliao Basin, over 50 million tons of crude oil was produced in Daqing Oilfield per year, which was paralleled by the development of continental petroleum geology theories. By the end of 1970s (1978) when crude yield amounted to 100 million tons, the theory of composite oil and gas accumulation zones of fault - depression basins was formed. At the beginning of the 21st century, Chinese petroleum industry enters into a new development stage. It is believed that with the publishing of *"Chinese Petroleum Geology and Onshore Exploration Strategy in the Early 21st Century"*, the formation, development, and further per-

fection of new theories of petroleum geology, together with the implementation of new strategies of onshore oil and gas exploration will promote to make major discoveries and breakthroughs in the upstream. A new increase peak of oil and gas reserves is expected to occur, boosting the great development in onshore petroleum industry in China.

Looking forward to the early 21st century and still longer in the future, the rapid growth of Chinese national economy is projected to continue, and oil and gas supply will face severe challenge. It is hoped that more petroleum geologists and exploration professionals take the responsibilities for the R&D of Chinese petroleum geology theories in the new period, promoting development of oil and gas exploration and production sector, and enhancing long-term, sustainable and rapid growth of Chinese petroleum industry. With the guidance of "*Chinese Petroleum Geology and Onshore Exploration Strategy in the Early 21st Century*", and by making joint efforts of vast numbers of petroleum geologists and explorers, new theories of petroleum geology is expected to be formed very soon, thus creating a new and bright future for Chinese petroleum industry!

Chen Geng
January 2005

PREFACE

China's petroleum industry has a long and glorious history. Chinese petroleum explorers and geologists have made great contributions through the history of oil and gas exploration. throughout the development of the petroleum industry, whenever there were dramatic increase in oil reserves and production, there have always been significant breakthroughs in the understanding of the basic laws of Chinese petroleum geology. In 1950s, Daqing Oilfield was discovered in the Songliao Basin after the development of the theory of hydrocarbon - forming from continental basins, loosening the limitation of marine facies oil and gas theory. At the end of 1970s, crude production in China reached 100 million tons per year. The main reason was breakthroughs made in Bohai Bay Basin, accompanied by the development of the theory of composite oil and gas accumulation zones in fault - depression basins. At the beginning of the 21st century, the Chinese petroleum industry has entered a new era of development. However, the domestic oil and gas supply meets severe challenges with the rapid development of the national economy. Exploration for natural gas has surpassed that of oil. The target of exploration has become more and more diversified and a great variety of basins, complicated oil and gas reservoirs, areas of different exploration scale, and frontiers and mature areas, have all become the focus of exploration. In this manner, we are faced with a completely new situation; how to maintain and increase the domestic oil and gas supply by developing new geological theories of oil and gas exploration to guide us towards new discoveries of oil and gas. This is a major task for oil and gas explorers and geologists. This also provides both challenges and new opportunities for the development of Chinese oil and gas exploration and relevant theory. China's petroleum industry is in need of new geological theory and proper onshore exploration strategy.

In recent years, the challenges faced by oil and gas exploration theory, practice of oil and gas exploration, the latest oversea theory introduction of sequence stratigraphy and the technological progress made in seismic and drilling engineering technology have actually promoted and helped the formation and development of new petroleum geological theories. The author believes that a new petroleum theory is in the process of formation and development. There will be a new onshore exploration theory in the beginning of the 21st century, which collects all new understanding and discoveries of exploration techniques in recent years, and absorbs new achievements in the research of fundamental geological disciplines. This is the collective wisdom of Chinese petroleum exploration researchers, which deserves to be named "China's oil and gas exploration theory of onshore lithological foreland deep

layer". It includes petroleum geology and exploration theory of lithologic – stratigraphic reservoirs, the structural geology of basins in central and western China, petroleum geology and exploration theory, petroleum geology and exploration theory of continental facies foreland basin thrusting belt, oil and gas reservoir formation and exploration theory in superposed basin medium and lower combination (deep layer), natural gas geology and enrichment theory, geological theory of unconventional oil and gas resources, and resource assessment and distributional prediction of remaining resources, and etc.

In the mean time, in the face of the resource situation and economic and technological conditions of China's onshore petroleum exploration in the early 21st century, the author perceives that China's onshore oil and gas exploration strategy in the early 21st century should be: focusing on lithologic – stratigraphic oil and gas reservoirs, foreland basin thrust belts, medium and lower combination (deep layer) of composite basins fine exploration of mature areas as principal exploration fields, and making the seven large basins like Songliao Basin and Tarim Basin as major exploration regions; intensifying oil exploration, accelerating natural gas exploration, actively advancing the risk exploration of new basins and new fields; emphasizing the development of such new technologies as applied seismology and drilling; reinforcing comprehensive geological research and fundamental petroleum geological disciplines research; and attaching importance to non – conventional oil and gas resources and new energy sources.

This book is the collection of the author's forty – seven academic papers published and lectures in various conferences in recent years, and the collection constitutes a preliminary summary of the author's pursuit, deep thinking and study results. Based on the decades of scientific research and exploration practice, the author comes to the conclusion that new scientific discoveries originated in the first – hand material from field studies and new thoughts about exploration derived from the exploration practice of our explorers. It is these new scientific discoveries and new thoughts on exploration that promote the formation of new theories on petroleum geology and exploration, and guide the development of oil and gas exploration. In recent years, the author has been making arduous efforts in petroleum geology research and exploration practice, and has obtained a number of results, some of which have been verified by the field exploration and played a positive role in our country's onshore oil and gas exploration. The author is particularly pleased that our colleagues in the petroleum exploration industry have made great efforts and scored considerable exploration progress in complicated geological regions, and have created a large number of new concepts and theories. The author hopes to absorb and synthesize these new thoughts and new theories of the petroleum community, and apply them into PetroChina's oil and gas exploration, to develop the new domestic theories of petroleum geology and exploration, and finally to form China's onshore oil and gas exploration strategy.

The author feels deeply that we, as petroleum explorers and petroleum geologists, undertake the glorious historical responsibility of guaranteeing our state petroleum security, and thus ensuring the healthy development of our national economy. In spite of the difficulties and risks ahead, the author is fully convinced that, with the common efforts of all professionals and experts of China's petroleum exploration industry, China's oil and gas exploration undertakings are in the ascendant, and we are certain to witness a new peak in the increase of China's petroleum reserves and embrace a splendid era in the natural gas industry. The author's heart-felt wish is that he can make his own contributions to this great undertaking through the publication of this book.

This book consists of two volumes which include six chapters. Volume one mainly discusses the issues of China's petroleum geological theory in the early 21st century, and is composed of Chapters One, Two and Three.

Chapter One: a discourse on China's onshore remnant oil and gas resources and major petroleum exploration fields in the future; a dissertation of the geological theory problems in lithologic-stratigraphic oil and gas reservoirs, foreland basin thrust belts, medium and lower combination (deep layer) of composite basins, discussion of the impact of the early 21st century petroleum geological theories, and introducing "China's exploration theories of onshore lithological foreland deep layer oil and gas in the early 21st century".

Chapter Two: a discourse on the petroleum geology, geotectonic background and formation characteristics of the central and west basins in China which are central to PetroChina's strategic replacement mission, indicating that small-scale craton basins, foreland basin thrusting belts and superposed and composite systems containing oil and gas are the typical geotectonic characteristics and petroliferous features in central and west basins in China. Tarim Basin and other basins in western China are one part of Tethys North Rim basin group which is one of the world's most significant natural gas reserve regions. Controlled by the unified geotectonic background of the Himalayan orogeny caused by the India-Tibet collision, China's central and west basins are clearly characterized by late oil and gas accumulation.

Chapter Three: a discourse on the types, structural evolution history and tectonic characteristics of Tarim Basin, pointing out that Tarim Basin is a large superposed and composite basin, which consisted of Palaeozoic cratonic basin and Mesozoic-Cenozoic foreland basins. It is characterized by the features of superposed and composite petroleum systems resulting from a complicated tectonic evolution history with multiple-phase deposition and uplift, diversiform oil sources, multiple oil-bearing layers, and multiple-phase accumulation. The distribution of oil and gas is mainly controlled by Palaeozoic cratonic uplift and Mesozoic and Cenozoic foreland basin thrusting belt. This chapter lays the foundation for superposed and composite basin theory and petroleum geological base in Tarim Ba-

sin, and plays an important role in guiding hydrocarbon exploration in Tarim Basin and even other central and west basins in China.

Volume Two mainly focuses upon China's onshore oil and gas exploration strategy in the early 21st century, and is composed of Chapters Four, Five and Six.

Chapter Four: a collection of the author's work reports released in the China Petroleum Exploration Annual Meeting and Exploration Technologies Symposium from 2000 to 2004. These reports elaborate on PetroChina's overall strategy and annual deployments in onshore oil and gas exploration, and constitute the author's conceptual plan and formation of thoughts on oil and gas distribution laws, exploration deployment decision making, and management of exploration strategy and organization. The reports also demonstrate the author's understanding, development planning and work on developing such exploration technologies as seismology, drilling and comprehensive geological research in recent years.

Chapter Five: Elaboration on the oil and gas exploration strategies in various basins. This chapter mainly consists of the author's speeches at Tarim, Junggar, Ordos, Qaidam, Jiuquan and Turpan – Hami basins exploration meetings and production sites, and include analysis of the oil and gas exploration situations in various basins, knowledge of oil and gas geological conditions and distribution laws, oil and gas exploration strategic deployment and relevant technological countermeasures.

Chapter Six: a discourse on petroleum exploration organization and management and technological development strategies under the new situation, including the organization and management of petroleum exploration, dominant exploration technology development trends, the current situation of fundamental petroleum scientific research and path of strengthening research, and the development of higher petroleum education. This chapter includes the historical overview, analysis of the current situation and the author's hopes and countermeasures.

Hereby, the author would like to express his heart – felt thanks to Academician Wang Tao, President Chen Geng, and Academician Qiu Zhongjian for their kind solicitude in so many years, express his appreciation to Academician Zhai Guangming, Academician Dai Jinxing, Academician Zhang Yiwei, Professor Gong Zaisheng, Professor Mou Shuling, and Professor Wang Yilin for their guidance, and thank his colleagues and friends Zhao Zhengzhang, Zhao Wenzhi, Jin Zhijun, Zhou Xinyuan, Song Yan, Ran Longhui, He Zixin, Du Jinhu, Zhou Haimin, Li Pilong, Zou Caineng, and Hu Suyun for their long – term support. The author also wants to thank the collaborators whose research results and theses are collected in this book. The author would like to acknowledge Wei Guoqi, Qian Kai, Guo Zhaojie and Lin Yonghan for their arduous efforts in the course of editing this book. Special thanks should go to Mr. Wei Guoqi for his significant contributions in particular.

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